

SANDIA REPORT

SAND87-0784 • UC-32  
Unlimited Release  
Printed October 1987

RS-8232-2I 66324

C1

8232-2/066324

00000001

# Langlie Test Method Program for Use With the HP-41CV/X Calculator

Michael R. Kopczewski

Prepared by  
Sandia National Laboratories  
Albuquerque, New Mexico 87185 and Livermore, California 94550  
for the United States Department of Energy  
under Contract DE-AC04-76DP00789

110966.9

Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation.

**NOTICE:** This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government, any agency thereof or any of their contractors or subcontractors. The views and opinions expressed herein do not necessarily state or reflect those of the United States Government, any agency thereof or any of their contractors or subcontractors.

Printed in the United States of America  
Available from  
National Technical Information Service  
U.S. Department of Commerce  
5285 Port Royal Road  
Springfield, VA 22161

NTIS price codes  
Printed copy: A03  
Microfiche copy: A01

SAND87-0784 UC-32  
Unlimited Release

Printed October 1987

**LANGLIE TEST METHOD PROGRAM  
FOR USE WITH THE HP-41CV/X CALCULATOR**

Michael R. Kopczewski  
Explosive Subsystems, 2512  
Sandia National Laboratories  
Albuquerque, NM 87185-5800

**ABSTRACT**

This report describes a Langlie "One-Shot" Test Method program for the HP-41CV/X calculator. The use of the calculator allows the user the freedom to implement this testing method at any site without reliance on the facilities computer.

## TABLE OF CONTENTS

	<u>Page</u>
I.     Introduction .....	6
II.    Explanation .....	7
III.   Program Review .....	12
IV.   Procedure .....	14
V.    References .....	15
VI.   Distribution .....	16
Appendix A .....	17
Appendix B.....	19
Appendix C .....	26

## ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
1	Sample "One-Shot" Test .....	9
2	Logic Flow Chart.....	10
3	Computing the Stress Levels .....	11
4	Program Flow Chart .....	13

## I. INTRODUCTION

Explosive component designers need to test the sensitivity of some unit response as a function level of stress, for example, the sensitivity of a detonator or ignitor bridgewire to input current. There exists a threshold level, above which the detonator will function and below which it will not. Statistical testing of explosive components often requires destructive testing of expensive hardware. If the unit functions, it is destroyed; and if it doesn't fire, the results from any further testing cannot be relied on because the initial test affects the detonator. In order to obtain meaningful results and not expend a large number of units, the Langlie "One-Shot" Method of testing is employed. Typical component attributes that require Langlie testing include "all-fire and "no-fire" tests to determine threshold levels of performance. Generally, any sensitivity testing lends itself to the Langlie method. This method has also been shown to be insensitive to design.<sup>2</sup>

Typically, support test groups and vendors implement the test method with their own computers. The method is subject to some interpretation which may lead to inconsistency in results from facility to facility. Another concern is that an error made in choosing a stimulus level will affect subsequent levels resulting in an analysis that is not a true Langlie. A program has been written for the HP-41CV/X calculator in order to standardize the Langlie test procedures at the various facilities and to minimize the possibilities of introducing errors in the test method. A distinct advantage of using the calculator is the ability to hand carry it in the field and perform the Langlie test method at remote locations.

## II. EXPLANATION

The following excerpt is from a paper entitled "A Reliability Test Method for "One-Shot" Items," by H. J. Langlie,<sup>1</sup> written August 10, 1962. Here, Langlie explains how the stress levels are selected.

### Selecting the Stress Levels

"Once the test interval and failure criteria have been established, the test commences by selecting the stress level at the midpoint of the interval. After exposing the first specimen to this environmental level and activating it, a one or zero is recorded to indicate the outcome as a success or failure respectively (see Figure 1).

"The general rule for obtaining the  $(n+1)^{\text{st}}$  stress level, having completed  $n$  trials, is to work backward in the test sequence, starting at the  $n^{\text{th}}$  trial, until a previous trial (call it the  $p^{\text{th}}$  trial) is found such that there are as many successes as failures in the  $p^{\text{th}}$  through  $n^{\text{th}}$  trial. The  $(n+1)^{\text{st}}$  stress level is then obtained by averaging the  $n^{\text{th}}$  stress level with the  $p^{\text{th}}$  stress level. If there exists no previous stress level satisfying the requirement stated above, then the  $(n+1)^{\text{st}}$  stress level is obtained by averaging the  $n^{\text{th}}$  stress level with the lower or upper limits of the test interval according to whether the  $n^{\text{th}}$  result was a failure or a success.

"To illustrate, suppose it is desired to find the second stress level in Figure 1. Since there was only one previous observation (i.e., first unit failed), it is not possible to find a stress level where all intervening results even out. That is, the second stress level is obtained by averaging the first with the lower limit. To find the eighth stress level, it observed that results from tests 4 through 7 (i.e., the last four results) cancel each other out. Thus, the eighth stress level is obtained by averaging the fourth level with the seventh.

"As a final example, it is observed that after the twelfth test has been completed, there again exists no previous stress level for which the number of failures equals the number of successes. Since the twelfth test was a failure, the thirteenth stress level is obtained by averaging the twelfth stress level with the lower limit."

The flow chart (Figure 2) serves to illustrate the logic for choosing the proper stress levels. The math table (Figure 3) illustrates step by step the computations used in Langlie's example.

The One-Shot method also assumes that the tolerance distribution is normal. Langlie gives no procedure for checking the validity of this assumption.<sup>2</sup>

It is very important to have a clear definition of what constitutes a failure or a success in any particular test. This definition is important in determining the next test level whenever the upper and lower limits must be used. In Langlie's example, achieving output from the device is a failure and not achieving output is a success. This would also be the case when running a no-fire test on detonators and ignitors. In the case of an all-fire test, achieving output is a success and no output is a failure.

**SAMPLE "ONE-SHOT" TEST**  
**TEST-TO-FAILURE OF THERMAL BATTERIES**

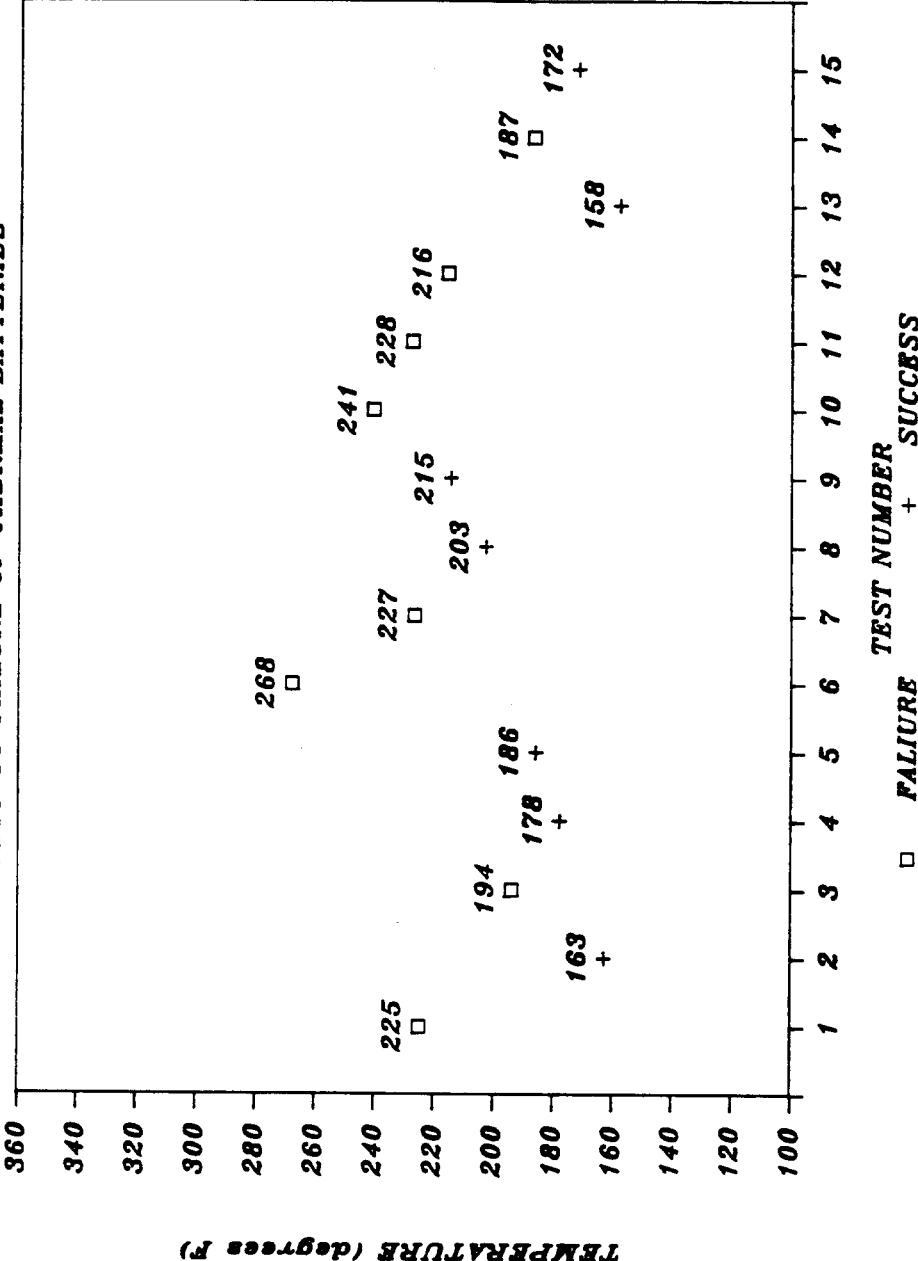


Figure 1. Sample "One-Shot" Test

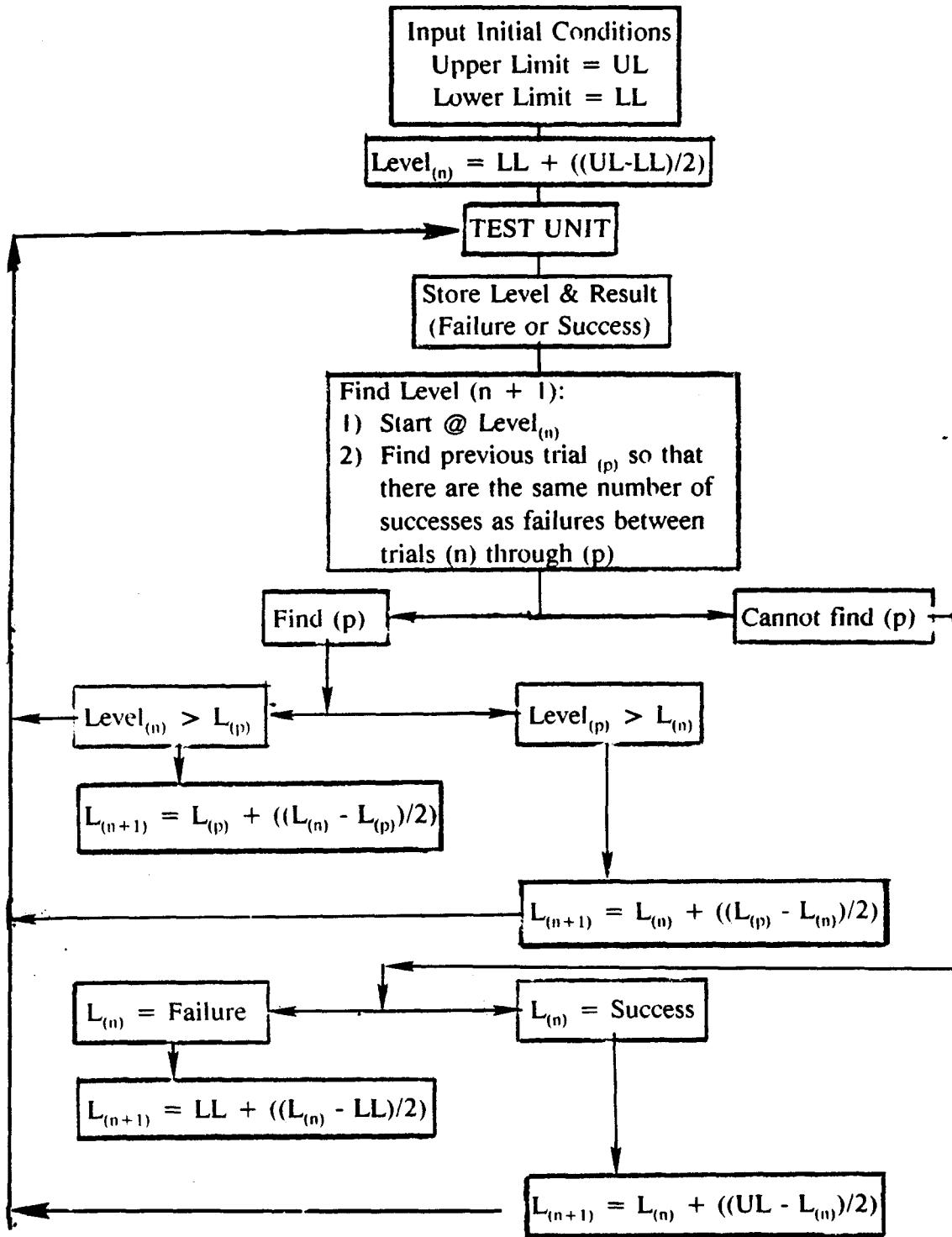


Figure 2. Logic Flow Chart

## COMPUTING THE STRESS LEVELS

Upper Limit = 350 degrees F

Lower Limit = 100 degrees F

If the Thermal Battery ignites at a temperature level, that is defined as a FAILURE or NOGO.

<u>Test #</u>	<u>Level</u>	<u>Result</u>	<u>Computation</u>
1	225	NoGo	$100 + ((350 - 100) / 2)$
2	163	Go	$100 + ((225 - 100) / 2)$
3	194	NoGo	$163 + ((225 - 163) / 2)$
4	178	Go	$163 + ((194 - 163) / 2)$
5	186	Go	$178 + ((194 - 178) / 2)$
6	268	NoGo	$186 + ((350 - 186) / 2)$
7	227	NoGo	$186 + ((268 - 186) / 2)$
8	203	Go	$178 + ((227 - 178) / 2)$
9	215	Go	$203 + ((227 - 203) / 2)$
10	241	NoGo	$215 + ((268 - 215) / 2)$
11	228	NoGo	$215 + ((241 - 215) / 2)$
12	216	NoGo	$215 + ((228 - 203) / 2)$
13	158	Go	$100 + ((216 - 100) / 2)$
14	187	NoGo	$158 + ((216 - 158) / 2)$
15	172	Go	$158 + ((187 - 158) / 2)$

Figure 3. Computing the Stress Levels

### III. PROGRAM OVERVIEW

This program was written for an HP-41CV/X calculator using the printer accessory. Its print-out consists of five sections:

- (1) Test Information. This section asks the user for information necessary to start the test. It asks for the test series identification, upper and lower limits, number of decimal places displayed in the level, what the stimulus is, and whether or not the user wants running statistics.
- (2) Test Data. This section informs the user what stimulus levels to use and asks whether the event was successful or a failure.
- (3) Statistics. This section computes the mean stimulus level as well as the standard deviation using the HP-41CV/X functions. These are defined as:

Mean:

$$x = \Sigma x/n$$

Standard Deviation:

$$s_x = \frac{(n\Sigma(x^2) - (\Sigma x)^2)}{n(n-1)}$$

- (4) Plot of Stimulus. This section draws a stimulus plot in order to give the user a visual aid in determining if the numbers look reasonable.
- (5) Table. This section tabulates the test results in a form that lends itself easily to inputting for the ASENT program.

The code itself consists of the main program called "LANGLIE." This program calls six subprograms: "STAT," "STATS," "MATHCAL," "TESTSEQ," "PLOT," "TABLE."

The program flow chart (Figure 4) is provided in order to illustrate the interaction of the seven programs. This program was field tested with the MRC/Mound Facility computer on the recent all-fire and no-fire testing of the MC3748 Insertable Initiator. The results were identical.

# PROGRAM FLOW CHART

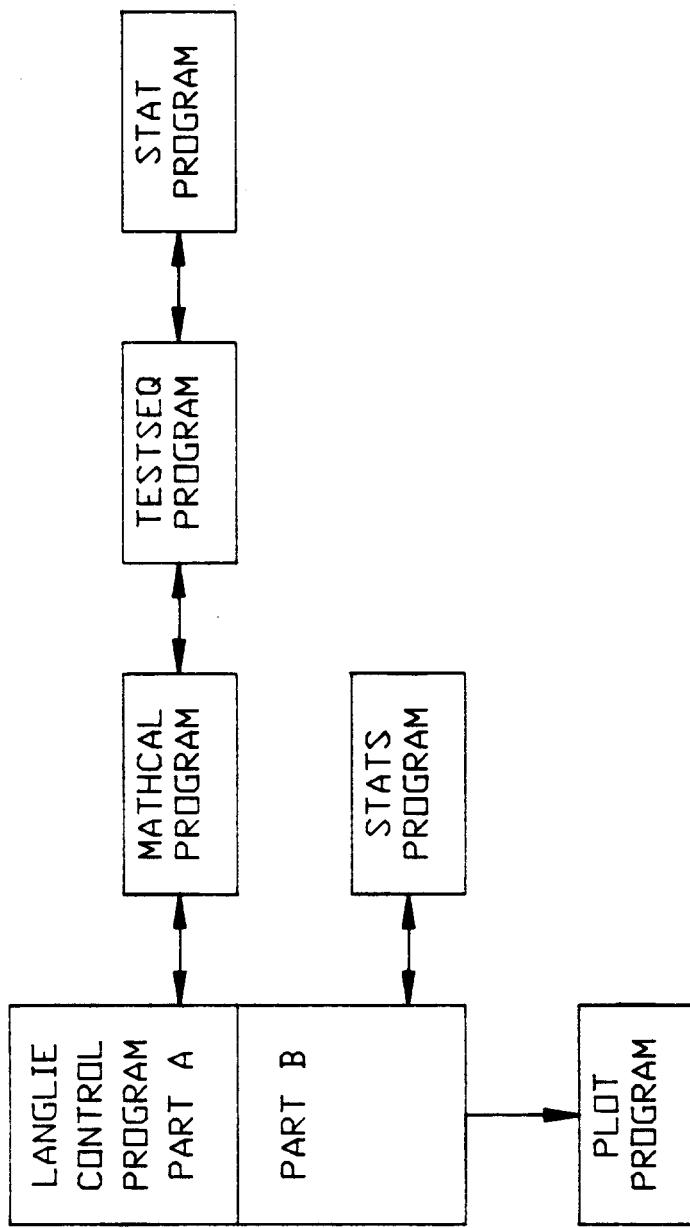


Figure 4. Program Flow Chart

#### IV. PROCEDURE

In order to run this program, it must be stored in the calculator memory. You can type it in or I have copies on the magnetic strips that can be read with a card reader.

Before running the program, enough registers must be set aside for data storage. To accomplish this, use the size command, "EXQ alpha SIZE alpha 100." The program uses some commands that are stored in the printer; therefore, the program will not run without the printer. The printer mode switch is to be set on manual.

To run the Program enter: "EXQ alpha LANGLIE alpha." Press the R/S button after each response that you key in.

The maximum number of units to be tested in any one run is thirty (30).

The output listing is shown in Appendix A. This run is a duplication of the "Thermal Battery" test that was described earlier in the article by Langlie. The actual program listings of the seven programs are listed in Appendix B. A listing of the memory registers and what they contain at the end of the run is in Appendix C. Appendix D contains all the program listings in bar code.

## V. REFERENCES

1. Langlie, H. J., "A Reliability Test Method for 'One-Shot' Items," Publication No. U-1792, Aeronautic, Newport Beach, California.
2. Edelman, D. A., Prairie, R. R., "A Monte Carlo Evaluation of the Bruceton, Probit, and One-Shot Methods of Sensitivity Testing," Publication No. SC\_RR\_66-59, Sandia National Laboratories, Albuquerque, New Mexico, March 1966.

## DISTRIBUTION

Mason & Hanger (4)

Silas Mason Co., Inc.

Pantex Plant

P.O. Box 30020

Amarillo, TX 79177

Attn: D. Garrett

R. Slape

D. Hilleary

N. Rhoton

Unidynamics/Phoenix, Inc. (3)

P.O. Box 2990

Phoenix, AZ 85062

Attn: R. Smith

P. Headley

W. Flemming

Ensign-Bickford Co. (3)

Aerospace Division

660 Hopmeadow St.

Simsbury, CT 06070

Attn: L. Mecca

K. Puls

E. Tarca

MRC/Mound Facility (3)

P.O. Box 32

Miamisburg, OH 45342

Attn: A. Munger

J. Powers

M. Zimmerman

2500 D. B. Hayes, Actg.

2510 D. H. Anderson

2512 J. G. Harlan

2512 All (15)

2512 M. R. Kopczewski (25)

2513 D. E. Mitchell

2513 All (7)

2514 L. L. Bonzon

2514 All (11)

2515 P. D. Wilcox

2515 All (10)

3141 S. A. Landenberger

3154-1 C. H. Dalin (28) for DOE/OSTI

3151 W. L. Garner (3)

7222 K. G. Pierce

8024 P. W. Dean

## Appendix A

### ONE SHOT TESTING

### H. J. LANGLIE METHOD

### TEST INFORMATION

TEST I.D.  
SAMPLE

NUM OF DECIMALS

1. \*\*\*

†GO LIMIT

350.0 \*\*\*

†NO-GO LIMIT

100.0 \*\*\*

†UNIT VALUE  
DEG. F

†NUM OF TESTS  
(MAX OF 30)

15. \*\*\*

RUNNING STATS  
†Y OR N  
N

### TEST DATA

TEST NUMBER 1.  
SET LEVEL TO =  
225.0 DEG. F  
FIRE  
†GO OR NO-GO  
NO

TEST NUMBER 2.  
SET LEVEL TO =  
162.5 DEG. F  
FIRE  
†GO OR NO-GO  
NO

TEST NUMBER 3.  
SET LEVEL TO =  
193.8 DEG. F  
FIRE  
†GO OR NO-GO  
GO

TEST NUMBER 4.  
SET LEVEL TO =  
178.2 DEG. F  
FIRE  
†GO OR NO-GO  
NO

TEST NUMBER 5.  
SET LEVEL TO =  
186.0 DEG. F  
FIRE  
†GO OR NO-GO  
NO

TEST NUMBER 6.  
SET LEVEL TO =  
268.0 DEG. F  
FIRE  
†GO OR NO-GO  
GO

TEST NUMBER 7.  
SET LEVEL TO =  
227.0 DEG. F  
FIRE  
†GO OR NO-GO  
GO

TEST NUMBER 8.  
SET LEVEL TO =  
202.6 DEG. F  
FIRE  
†GO OR NO-GO  
NO

TEST NUMBER 9.  
SET LEVEL TO =  
214.8 DEG. F  
FIRE  
†GO OR NO-GO  
NO

TEST NUMBER 10.  
SET LEVEL TO =  
241.4 DEG. F  
FIRE  
†GO OR NO-GO  
GO

TEST NUMBER 11.  
SET LEVEL TO =  
228.1 DEG. F  
FIRE  
†GO OR NO-GO  
GO

TEST NUMBER 12.  
SET LEVEL TO =  
215.4 DEG. F  
FIRE  
†GO OR NO-GO  
GO

TEST NUMBER 13.  
SET LEVEL TO =  
157.7 DEG. F  
FIRE  
†GO OR NO-GO  
NO

TEST NUMBER 14.  
SET LEVEL TO =  
186.6 DEG. F  
FIRE  
†GO OR NO-GO  
GO

TEST NUMBER 15.  
SET LEVEL TO =  
172.2 DEG. F  
FIRE  
†GO OR NO-GO  
NO

### MEAN STIMULUS

MEAN = 204.0 deg. f

### STANDARD DEVIATION

ST. DEV. = 31.1 deg. f

## Appendix A

PLOT OF STIMULUS		TEST RESULTS
X=TEST NUMBER		SAMPLE
Y=STIMULUS DEG. F		TEST LEVEL GO/NO
X (UNITS= 1)4		1. " 225.0" "GO
Y (UNITS= 1.) +		2. " 162.5" "NO
100.	350.	3. " 193.8" "GO
204.		4. " 178.2" "NO
1.	+	5. " 186.0" "NO
2.	+	6. " 268.0" "GO
3.	+	7. " 227.8" "GO
4.	+	8. " 282.6" "NO
5.	+	9. " 214.8" "NO
6.	+	10. " 241.4" "GO
7.	+	11. " 228.1" "GO
8.	+	12. " 215.4" "GO
9.	+	13. " 157.7" "NO
10.	+	14. " 186.6" "GO
11.	+	15. " 172.2" "NO

ANOTHER RUN?  
YY OR N  
N

END OF RUN  
n.r. koczeuski  
division 2512

## Appendix B Langlie

01LBL "LNGLIE"	61 "TMU-GU LIMIT"	121 ADV
02 CLRG	62 TONE 8	122 ADV
03 CLΣ	63 PROMPT	123 XEQ "PLOT"
04 ΣREG 82	64 PRA	124 ADV
05 28	65 STO 02	125 END
06 STO 04	66 STO 07	
07 21	67 PRX	
08 STO 17	68 "UNIT VALUE"	
09 51	69 TONE 8	
10 STO 05	70 PRA	
11 FIX 0	71 TONE 8	
12 "NO"	72 AON	
13 ASTO 00	73 PROMPT	
14 "Y"	74 PRA	
15 ASTO 97	75 ASTO 14	
16 SF 12	76 ROFF	
17 "ONE SHOT"	77 "	
18 PRA	78 ASTO 15	
19 "TESTING"	79 FIX 0	
20 PRA	80 ADV	
21 ADV	81 "NUM OF TESTS"	
22 "H.J. LANGLIE"	82 PRA	
23 PRA	83 "(MAX OF 30)"	
24 "METHOD"	84 TONE 8	
25 PRA	85 PROMPT	
26 ADV	86 PRA	
27 ADV	87 STO 06	
28 ADV	88 PRX	
29 SF 12	89 FIX IND 98	
30 "TEST"	90 ADV	
31 PRA	91 "RUNNING STATS"	
32 "INFORMATION"	92 PRA	
33 PRA	93 "Y OR N"	
34 ADV	94 PRA	
35 CF 12	95 TONE 8	
36 "TEST I.D."	96 AON	
37 PRA	97 PROMPT	
38 AON	98 PRA	
39 TONE 8	99 ASTO Y	
40 PROMPT	100 CLR	
41 PRA	101 ARCL 97	
42 ASTO 98	102 ASTO X	
43 ROFF	103 X=Y?	
44 ADV	104 SF 05	
45 "NUM OF DECIMALS"	105 ROFF	
46 PRA	106 ADV	
47 TONE 8	107 ADV	
48 PROMPT	108 SF 12	
49 STO 98	109 "TEST"	
50 PRX	110 PRA	
51 CLX	111 "DATA"	
52 FIX IND 98	112 PRA	
53 "GO LIMIT"	113 CF 12	
54 TONE 8	114 ADV	
55 PROMPT	115 XEQ "MATHCAL"	
56 PRA	116 ADV	
57 ENTER†	117 CF 05	
58 PRX	118 ADV	
59 STO 01	119 CLΣ	
60 STO 03	120 XEQ "STATS"	

## Appendix B Testseq

```
01+LBL "TESTSEQ"
02 "SET LEVEL TO ="
03 AVIEW
04 CLA
05 ARCL X
06 ARCL 15
07 ARCL 14
08 AVIEW
09 "FIRE"
10 AVIEW
11 TONE 9
12 TONE 8
13 TONE 7
14 TONE 6
15 TONE 5
16 TONE 4
17 TONE 3
18 TONE 2
19 TONE 1
20 AON
21 CLX
22 CLA
23 "GO OR NO-GO"
24 PRA
25 PROMPT
26 PRA
27 ASTO X
28 ASTO 95
29 CLA
30 FS? 05
31 XEQ "STAT"
32 CLX
33 CLA
34 ARCL 95
35 ASTO X
36 CLA
37 ARCL 06
38 ASTO Y
39 CLA
40 X=Y?
41 GTO 01
42 1
43 RTH
44+LBL 01
45 -1
46 RTH
47 END
```

## Appendix B Mathcal

01•LBL "MATHCAL"	61 RCL IND 08
02•LBL 01	62 STO 07
03 1	63 GTO 07
04 ST+ 04	64•LBL 05
05 ST+ 05	65 RCL IND 12
06 ST+ 13	66 1
07 RCL 05	67 -
08 STO 12	68 X=0?
09 82	69 GTO 06
10 -	70 RCL IND 04
11 X=0?	71 STO 07
12 RTN	72 RCL 01
13 RCL 13	73 STO 03
14 1	74 GTO 07
15 -	75•LBL 06
16 RCL 06	76 RCL IND 04
17 X=Y?	77 STO 07
18 RTN	78 RCL 02
19 FIX 0	79 STO 03
20 RCL 13	80 GTO 07
21 ADV	81•LBL 07
22 "TEST NUMBER "	82 0
23 ARCL X	83 STO 08
24 AVIEW	84 RCL 12
25 FIX IND 98	85 STO 05
26•LBL 02	86 GTO 01
27 RCL 03	87 END
28 RCL 07	
29 -	
30 2	
31 /	
32 RCL 07	
33 +	
34 RND	
35 STO IND 04	
36 XEQ "TESTSEQ"	
37 STO IND 05	
38•LBL 03	
39 ST+ 08	
40 RCL 08	
41 X=0?	
42 GTO 04	
43 1	
44 ST- 05	
45 RCL 05	
46 58	
47 -	
48 X=0?	
49 GTO 05	
50 RCL IND 05	
51 GTO 03	
52•LBL 04	
53 RCL IND 04	
54 STO 03	
55 RCL 12	
56 RCL 05	
57 -	
58 RCL 04	
59 -	
60 STO 08	

## Appendix B Stat

```
01LBL "STAT"
02 RCL 13
03 2
04 X<=Y?
05 GTO 01
06 21
07 STO 94
08 RCL 21
09 Σ+
10 1
11 ST+ 94
12 RCL 13
13 X=Y?
14 RTN
15LBL 01
16 RCL INI 94
17 Σ+
18 1
19 ST+ 94
20 "MEAN"
21 PRA
22 MEAN
23 PRX
24 "SDEV"
25 PRA
26 SDEV
27 PRX
28 ADV
29 RTN
30 END
```

## Appendix B Stats

01LBL "STATS"	61 ACX
02 RCL 06	62 SF 13
03 21	63 ARCL 15
04 +	64 ARCL 14
05 STO 16	65 ACA
06LBL 01	66 PRBUF
07 RCL IMD 17	67 CF 13
08 Σ+	68 ADV
09 1	69 ADV
10 ST+ 17	70 RTN
11 RCL 17	71 END
12 RCL 16	
13 X?Y?	
14 GTO 01	
15 MEAN	
16 STO 18	
17 SDEV	
18 STO 11	
19 ADV	
20 SF 12	
21 "MEAN"	
22 PRA	
23 "STIMULUS"	
24 PRA	
25 ADV	
26 CF 12	
27 "MEAN"	
28 CLA	
29 "MEAN"	
30 ACA	
31 CLA	
32 125	
33 ACCHR	
34 ACR	
35 CLA	
36 RCL 18	
37 ACX	
38 SF 13	
39 ARCL 15	
40 ARCL 14	
41 ACA	
42 PRBUF	
43 CF 13	
44 ADV	
45 ADV	
46 SF 12	
47 "STANDARD"	
48 PRA	
49 "DEVIATION"	
50 PRA	
51 CF 12	
52 ADV	
53 "ST. DEV."	
54 ACA	
55 CLA	
56 125	
57 ACCHR	
58 ACA	
59 CLA	
60 RCL 11	

## Appendix B Plot

01LBL "PLOT"	61 STO 12
02 RCL 06	62 1
03 1	63 STO 11
04 +	64LBL 01
05 STO 18	65 RCL 11
06 SF 12	66 ACX
07 "PLOT"	67 RCL IND 12
08 PRA	68 REGPLOT
09 7	69 1
10 "OF"	70 ST+ 11
11 PRA	71 ST+ 12
12 "STIMULUS"	72 RCL 18
13 PRA	73 RCL 11
14 CF 12	74 X=Y?
15 ADV	75 GTO 02
16 "X=TEST NUMBER"	76 GTO 01
17 PRA	77LBL 02
18 "Y=STIMULUS"	78 RDY
19 ARCL 15	79 RDY
20 ARCL 14	80 RDY
21 AVIEW	81 RDY
22 ADV	82 XEQ "TABLE"
23 4	83 RDY
24 SKPCHR	84 RDY
25 "X"	85 "Y"
26 ACA	86 ASTO Y
27 CLA	87 CLA
28 " (UNITS= 1)"	88 "ANOTHER RUN?"
29 ACA	89 PRA
30 7	90 "Y OR N"
31 ACCHR	91 PRA
32 PRBUF	92 CLA
33 RCL 02	93 BEEP
34 STO 00	94 AON
35 RCL 01	95 PROMPT
36 STO 01	96 PRA
37 RCL 10	97 ROFF
38 STO 04	98 RDY
39 138	99 RDY
40 STO 02	100 ASTO X
41 0	101 X=Y?
42 ENTER†	102 XEQ "LANGLIE"
43 0	103 "END OF RUN"
44 BLDSPEC	104 0
45 28	105 STO 08
46 BLDSPEC	106 STO 07
47 85	107 PRA
48 BLDSPEC	108 SF 13
49 127	109 "M.R. KOPCZEWSKI"
50 BLDSPEC	110 PRA
51 85	111 CLA
52 BLDSPEC	112 "DIVISION 2512"
53 28	113 PRA
54 BLDSPEC	114 CF 13
55 0	115 TONE 4
56 BLDSPEC	116 TONE 5
57 STO 03	117 TONE 6
58 XROM "PRAXIS"	118 TONE 5
59 FIX 0	119 TONE 0
60 21	120 RTN
	121 END

## Appendix B Table

01LBL "TABLE"	61LBL D
02 "NO"	62 ARCL 92
03 ASTO 92	63LBL E
04 "GO"	64 ACA
05 ASTO 91	65 PRBUF
06 SF 12	66 CLA
07 "TEST"	67 1
08 PRA	68 RCL 88
09 "RESULTS"	69 +
10 PRA	70 STO 86
11 ADV	71 1
12 CF 12	72 RCL 19
13 CLA	73 +
14 ARCL 90	74 STO 19
15 PRA	75 1
16 ADV	76 RCL 28
17 "TEST"	77 +
18 ACA	78 STO 28
19 " LEVEL"	79 ADV
20 ACA	80 GTO A
21 " GO/NO"	81LBL B
22 ACA	82 ADV
23 PRBUF	83 END
24 1	
25 STO 88	
26 "	
27 ASTO 89	
28 PRBUF	
29 CLA	
30 1	
31 RCL 87	
32 +	
33 STO 87	
34 21	
35 STO 19	
36 52	
37 STO 20	
38LBL A	
39 RCL 88	
40 RCL 87	
41 X=Y?	
42 GTO B	
43 FIX 0	
44 RCL 88	
45 ACX	
46 RCL 89	
47 ACX	
48 FIX IND 98	
49 RCL IND 19	
50 ACX	
51 RCL 89	
52 ACX	
53 1	
54 RCL IND 20	
55 X=Y?	
56 GTO C	
57 GTO D	
58LBL C	
59 ARCL 91	
60 GTO E	

## Appendix C

### LISTING OF MEMORY REGISTERS

R0= LOWER LIMIT  
R1= UPPER LIMIT  
R2= WORKING LOWER LIMIT  
R3= PRINT CHARACTER  
R4= X COUNTER  
R5= N COUNTER  
R6= T (NUMBER OF TESTS)  
R7= WORKING UPPER LIMIT  
R8= Y(PRIME)  
R9= TEST RESULT WORKING BUFFER  
R10= MEAN  
R11= STANDARD DEVIATION  
R12= LIMIT  
R13= R  
R14= UNIT VALUE  
R15= "SPACE"  
R16= STATISTICAL CALCULATIONS  
R17= COUNTER LIMIT  
R18= PLOTTER  
R19= PLOTTER  
R20= COUNTER  
R21---R51= TEST LEVELS  
R52---R81= GO & NOGO RESULTS  
R82---R88= STATISTICS REGISTERS  
R89= "SPACE"  
R90= "NAME OF TEST"  
R91= "GO"  
R92= "NO"  
R93= 0  
R94= 0  
R95= "NO"  
R96= 0  
R97= "Y"  
R98= 1  
R99= 0

## Appendix C

R00= 100.0	R61= 1.0
R01= 350.0	R62= 1.0
R02= 130.1	R63= 1.0
R03= "e.uN"	R64= -1.0
R04= 204.0	R65= 1.0
R05= 54.0	R66= -1.0
R06= 1.0	R67= 0.0
R07= 186.6	R68= 0.0
R08= 0.0	R69= 0.0
R09= 0.0	R70= 0.0
R10= 204.0	R71= 0.0
R11= 16.0	R72= 0.0
R12= 36.0	R73= 0.0
R13= 16.0	R74= 0.0
R14= "DEG. F"	R75= 0.0
R15= "	R76= 0.0
R16= 36.0	R77= 0.0
R17= 36.0	R78= 0.0
R18= 16.0	R79= 0.0
R19= 36.0	R80= 0.0
R20= 67.0	R81= 0.0
R21= 225.0	R82= 3,059.3
R22= 162.5	R83= 637,522.2
R23= 193.8	R84= 540.0
R24= 178.2	R85= 19,440.0
R25= 186.0	R86= 110,134.8
R26= 268.0	R87= 0.0
R27= 227.0	R88= 0.0
R28= 202.6	R89= - -
R29= 214.8	R90= "SAMPLE"
R30= 241.4	R91= "CO"
R31= 228.1	R92= "HO"
R32= 215.4	R93= 0.0
R33= 157.7	R94= 0.0
R34= 186.6	R95= "NO"
R35= 172.2	R96= 0.0
R36= 0.0	R97= "Y"
R37= 0.0	R98= 1.0
R38= 0.0	R99= 0.0
R39= 0.0	
R40= 0.0	
R41= 0.0	
R42= 0.0	
R43= 0.0	
R44= 0.0	
R45= 0.0	
R46= 0.0	
R47= 0.0	
R48= 0.0	
R49= 0.0	
R50= 0.0	
R51= 0.0	
R52= 1.0	
R53= -1.0	
R54= 1.0	
R55= -1.0	
R56= -1.0	
R57= 1.0	
R58= 1.0	
R59= -1.0	
R60= -1.0	